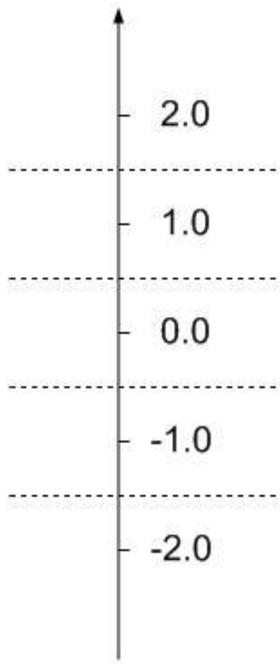
Stevens Institute of Technology
Department of Electrical and Computer Engineering

Spring Semester 2025

CpE 462 Introduction to Image Processing

Homework 8: Due May 1

8.1 Quantization and Huffman coding



8.1.1 Use a 5-level uniform scalar quantizer as shown to quantize the sample sequence {0.25, -1.10, -0.15, 2.35, -1.40, 0.10, 0.90, -0.05}. Provide the output sequence.

8.1.2 Design the best fixed-length code for the outputs of this quantizer, i.e. for an alphabet A={2.0, 1.0, 0.0, -1.0, -2.0}. Then encode the quantization output sequence from 8.1.1 using this code.

8.1.3 Design a Huffman code for the same alphabet A = {2.0, 1.0, 0.0, -1.0, -2.0} assuming the probabilities P(2.0)=0.15, P(1.0)=0.20, P(0.0)=0.40, P(-1.0)=0.15, P(-2.0)=0.10. Then encode the quantization output sequence from 8.1.1 using this code.

8.2 Differential Coding (assuming there is no quantization or coding error, i.e. $\hat{x}[n] = x[n]$)

8.2.1 Use differential coding with the predictor $\tilde{x}[n] = \hat{x}[n-1]$ to encode the sequence
10 11 12 11 12 13 12 11

8.2.2 Use the same predictor to encode another sequence
10 -10 8 -7 8 -8 7 -7

8.2.3 Find a better linear predictor for this second sequence in 8.2.2.and perform the differential coding again. (Hint: your objective is to make sure the coded sequence has generally low amplitudes.)

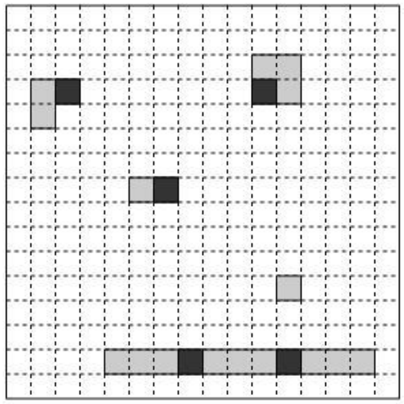
8.3 In a JPEG image coder, after the DCT, quantization and zig-zag scanning, all the AC coefficients are coded through a run-length coding. This run-length coding is defined as pairs of (*zero-run*, *amplitude*), where the *amplitude* is a non-zero coefficient and the *zero-run* is the number of zeros prior to this non-zero coefficient. At a certain point when there is no more non-zero coefficient in the block, a symbol EOB (end-of-block) is coded.

1. Now open image "**lenna.256**" in Matlab and process the first 8×8 block and name it x1:

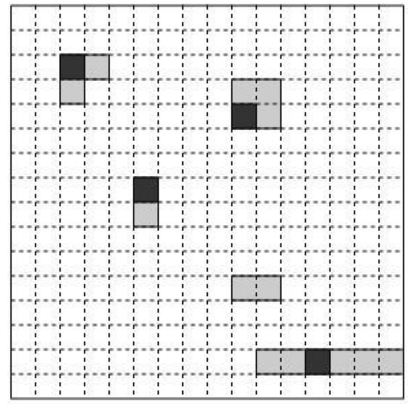
   ```
   fid=fopen('lenna.256','r');
   x=fread(fid,[256,256],'uchar');
   fclose(fid);
   x1=x(1:8,1:8);
   ```

2. apply 2D DCT on this block use "dct2" function (<u>in Matlab</u>);
3. apply the quantization table ***Q*** on page 8 of Lecture 10 (<u>in Matlab</u>);
4. perform zig-zag scan and generate the run-length pairs (<u>by hand</u>);
5. Repeat 3 and 4 with a scaled quantization table **0.1*Q***.

8.4 Based on the motion compensated estimation used in MPEG, find the motion vectors, the prediction frame and the difference frame for the current frame as shown. Assume each box represents a pixel, each macro-block is of 2×2 pixels, the white boxes have value of zero (0), the gray boxes have value of one (1), and the black boxes have value of two (2).



Referemce Frame



Current Frame